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**Before the  
U.S. Senate Committee on Commerce, Science and Transportation,  
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**Hearing on “NASA at a Crossroads: Reasserting American Leadership in Space  
Exploration”**

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Chairman Cruz, Ranking Member Peters, and Members of the Committee, thank you for the opportunity to discuss my thoughts on leadership in space exploration. First, I must be clear: in my mind, reasserting leadership in space exploration involves more than just NASA, it extends to the broader space exploration community- industry, emerging space companies, space research communities, the general public and, most importantly, future generations of explorers, to whom we are **all** accountable. This community, those of us on this Earth who are lucky enough to share a passion for space exploration, live today on the shoulders of those that have taken us to the moon, extended our view into deep space, robotically explored the solar system and beyond, and developed the International Space Station. We owe it to the next generation to do for them that which our predecessors accomplished for us.

Yes, we are indeed at a crossroads as the title of the hearing suggests - but a crossroads where NASA is on the cusp of transition. Not just transition in the political sense, but a transition in exploration. NASA has focused on LEO for the past 40 years but the capabilities (Orion, SLS, GSDO) to again get humans beyond LEO to the Moon, Mars, and beyond are nearing completion in design and development putting us on the cusp of a new era in exploration that we have spent decades dreaming about. The capabilities being built today will enable the return of humans to the area around the Moon, the human exploration of Mars, and beyond, and the possibility of answering the Big 3 science questions: Where did we come from? Where are we going? Are we alone?

At the same time, NASA's 40+ years of investment in low earth orbit have blazed a trail that has opened up economic possibilities, rewritten science textbooks, and is beginning to address ageing issues as we learn from zero-gravity-- not to mention all the applications that have spun off from this investment to make things better here on Earth.

Space exploration requires long-term focus, commitment and investment. I emphasize commitment because exploration is both challenging and risky, and the payoffs are spread over the longer term. Using the roles of government and commercial entities in the correct balance, technical risks are reduced, eventually opening up new markets in space for investment. Through space exploration we also gain new scientific knowledge for application on Earth, as well as new technologies to further U.S. economic leadership and develop innovative global markets. In addition, exploration serves to continually challenge human capabilities and feed human curiosity.

In my opinion, it is imperative that the United States, and its international partners, continues to pursue and build upon their existing commitments of space exploration to extend humanity's reach into deep space. In the past, however, there have been major financial and programmatic disruptions to NASA's space exploration activities. These changes have: misspent taxpayer resources, confused the general public, demoralized a talented workforce, and diminished or wasted technical and economic capability. The result left exploration efforts *slowly creeping*, rather than *boldly going* forward... a position significantly below this nation's capability. Let me state unequivocally, I believe that **improvement** must be continuous, challenge the status quo, and enhance our capabilities for the future. My experience at NASA, and now preparing the next generation, has taught me that change is often needed, but also that disruption often yields changes, but not necessarily improvement.

My lessons learned in the 2009-2011 timeframe, concerning the changes to the NASA human exploration budget and associated program adjustments, were many. In addition, program planning and implementation challenges through 2014 provided further lessons. I would like to discuss these lessons and provide suggestions for moving forward.

The key lessons and their impacts are:

- 1) **"Why" We continue to explore space has not been well communicated.** The result is a lack of understanding and "buy-in" from the American public and all .. This directly leads to an unhealthy state of individual ideas being argued with minimal possibility of consensus and integration.
- 2) **Debates over specific destinations generate "camps" and an unhealthy environment of "our" plan versus "their" plan.** In reality, the destinations are, at best, secondary to the real need of near and far term benefits for society.
- 3) **Continuity of purpose and execution is essential for efficient use of resources and timely, tangible accomplishment.** Cancellation of major programs, or making significant changes to programs, thwarts continuity.
- 4) **Budget stability and appropriate funding growth is critical to keeping exploration programs on schedule.**

All of these lessons must be addressed to maintain U.S. leadership in space exploration and efficiently execute the programs.

It is imperative that as a nation, and a global community, we address these lessons to obtain the benefits of space exploration.

With similar and coordinated actions, we can address the lessons of communicating the “why we explore” and the related debate over destinations. A dedicated, and transparent effort, which works toward building AND maintaining consensus on why we explore is needed. This must be combined with an associated top-level strategy. This is not a one-time activity, this should be a continual effort with NASA, the aerospace industry - including emerging space companies, researchers, politicians, marketing and communications experts, cultural thinkers and writers, and representatives of the interested general public. This effort must consider what is needed to enlarge a space economy, engage the general public and their representatives, and how NASA and government investment can best support space exploration. The 2014 National Research Council, “*Pathways to Exploration*” report provides a sound starting point for this activity. This report engaged the needed perspectives and cross-sections to arrive at its conclusions.

Secondly, we need to focus on what needs to be accomplished, and how to accomplish it, in order to develop a thriving space economy. To get past the destination discussion, a coordinated strategy for this development is required. Comments circulated during previous transitions, in reference to the Moon as a “*been there, done that, got the t-shirt*” destination are unproductive. There were also incorrect claims that NASA did not plan on going to Mars. Finally, the often intoned “Moon” versus “Mars” versus “asteroids” argument, led only to a fight between the respective camps. The space exploration community was “shooting inward”, not communicating an organized strategy.

A sustainable exploration strategy is what is needed. This requires an immediate cessation of “shooting inward” and recognition of what is sustainable. Sustainability requires a communicated strategy and that implementation programs be executable and accomplish milestones. The strategy must be affordable and include international partners on the critical path. Clear expectations and use of the appropriate roles for government and private industry will support building a consensus strategy.

Continuity of purpose and execution pairs well with budget stability. When the NASA Constellation program was cancelled in FY 2011, significant progress had already been made. Unquestionably, there was need for improvement in the planning and execution of Constellation. However, effectively canceling a five-year, \$9 billion effort resulted in loss of momentum in all projects (Ares, Orion, Ground Systems), massive re-planning of the on-going Constellation activities, and loss of talent across the Agency, particularly at NASA’s Johnson, Kennedy, and Marshall

Centers. Hundreds of prime and support contractor jobs, along with those at suppliers, were eliminated due to this major policy change.

Paired with continuity is budget stability. This was a key topic in my testimony to the House Science Committee in October 2015. As part of the effort to respond to the 2010 NASA Authorization Act (Public Law 111-267), the Office of Management and Budget directed NASA to plan human exploration efforts (what became Orion, the Space Launch System or SLS, and Ground Systems) within a \$3B annual funding level, without inflation over the budget horizon. This established the SLS configuration, and programmatic phasing for the Exploration Systems efforts. However, the annual budget requests were consistently less, FY2012 - \$2.81B, FY2013-\$2.76B, FY2014-\$2.73B. Each year, Congress increased appropriations to near the \$3B level, and in FY2014 appropriated over \$3.1B. This annual appropriations debate results in continuous re-planning, loss of team focus on very challenging technical tasks, programmatic delays, and confusion and miscommunication across the team, and among all stakeholders.

Continuing resolutions, government shutdowns, brinksmanship in the national appropriations process, and tardiness in receiving final appropriations all adversely impact budgetary stability. These national level budget debates lead directly to program cost and schedule changes. They serve to increase confusion, and result in loss of focus due to constant revision. For example, the fifteen-day government shutdown in October 2013 resulted in overall Exploration System inefficiencies of at least \$240M, accounting for 1 week of phase down, 2 weeks of shutdown, 1 week of ramp up.

***“Conquering the universe one has to solve two problems: gravity and red tape. We could have mastered gravity.” – Dr. Wernher von Braun***

For space exploration leadership, it is essential to maintain continuity of purpose, coupled with budgetary stability. This results in efficient program implementation. Continuity across Administrations, and stable budget requests and appropriations, will provide the strong foundation for building an executable consensus strategy that can be well communicated with all stakeholders. Stable budgets, that allow for program planning over the budget horizon, including inflation to maintain purchasing power, are critical to continued progress. Budgets should grow and be commensurate with the work required in any given year and then grow as needed to develop and operate the essential exploration elements – currently to include SLS, Orion, and habitats. Today, there are over 8000 talented workers across all 50 states developing and building these systems, in addition to the European Orion service module.

Additionally, it should be recognized that Administration changes, driven by the voice of the voters, can adjust exploration priorities and strategies due to economic or security concerns. Such adjustments, however, should not indiscriminately eliminate or alter major programs without addressing proper and sufficient

coordination among all stakeholders. Space exploratory goals should adjust based on what is discovered through progress and innovation.

In conclusion, I can attest through personal experience that space exploration is relevant across the globe. Researchers, rocket scientists, academics, both University and elementary students and stargazers from all walks of life, express enthusiasm for emerging launch systems, be they built by NASA, Blue Origin, ULA, or SpaceX. International Space Agencies eagerly host groups of engineering students keen to become the next trailblazers, improving our awareness of the universe. With so many on Earth eager to explore, it is imperative that we take lessons from the past, benefit from that knowledge and fashion a space exploration strategy that is unanimous, continuous, communicated, sustainable and suitably funded.

Thank you for this opportunity to speak, thank you for your time and attention, and I look forward to your questions.